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CLINICAL STUDY OF THE EFFECT OF AIR POLLUTION UPON ASTHMATIC PATIENTS

T. Ishizaki*, J. Kabe, M. Tomaru, and K. Nakagawa**

ABSTRACT. Fifteen asthmatic patients of atopic type at the Tokyo Kyosai Hospital were followed up regarding their symptoms through the asthma patient diary prepared by the present authors during the period from November 18, 1969, to February 6, 1970, and the hourly changes of air pollutants (SO_2 and suspended particles) were measured and recorded automatically by an air pollution recorder settled in this hospital.

The day of ingravescent symptoms especially with asthamtic attacks was checked for each patient during the observation period, and the patient number of ingravescent symptoms in each day was recorded and analyzed for the health effect of air pollution. The asthmatic patients showed a tendency to develop critical symptoms on the day when severe air pollution of SO_2 over 0.2 ppm maximum took place (during the day) and also when suspended particles were over 50% by the measurement of transparency decrease of filter paper. The influence of severe air pollution upon asthmatic attack seemed to continue to the subsequent day.

Although the lung function tests using a Benedict Roth respirometer, as well as Body pletysmograph, were investigated. On more than six patients, no significant correlation was recognized between the data of the tests and the air pollution factors.

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1. FOREWORD

Many reports [1 — 7], including those by the authors of this article, cite statistics showing how air pollution tends to aggravate the symptoms of bronchial asthma. Also, clinical studies indicate that asthmatic patients are far more sensitive [7 — 8] to sulfur dioxide than normal persons.

By having asthmatic patients maintain a daily diary of their symptoms, the authors studied the correlation of atmospheric factors to asthmatic attacks and were able to determine that such attacks usually occurred on days when it was rainy or unsettled (passing of the weather front), that the patients felt better on clear, bright days, and that lower humidity increased chances for an asthmatic attack [6]. At the same time, the effect of air pollution was also studied. However, the relationship of air pollution and asthmatic attacks could not then be clarified as the patients needed for the survey were located in metropolitan Tokyo and outlying prefectures, coupled with difficulties of establishing appropriate air pollution recording stations. Not so long ago, an automatic air pollution recorder was installed in the Tokyo Kyosai Hospital in Naka-Meguro, Meguro-ku, where 15 asthmatic patients of the atopic type, not on steroid drugs, characterized by intermediate to light symptoms and residing within a radius of 2000 meters of the hospital (most lived within 1000 meters, however) were selected for the test. From their diaries, it was possible to determine the days on which the patients were most prone to such attacks, as well as their link to air pollution. The results of the study are described below.

2. RESEARCH GOAL AND RESEARCH METHOD

1. Research Goal

The research was conducted among 15 atopic, asthmatic out patients of the Allergy Department, Internal Medicine Division of Tokyo Kyosai Hospital in Naka-Meguro, Meguro-ku, Tokyo, suffering from stridor and light asthmatic attack, but not on steroids (see Table 2 for sex, age, etc., of the patients).

The majority of the patients selected resided within a radius of 1000 meters of the hospital, some within 2000 meters. After their initial diagnosis, the patients were required to keep a daily record of their symptoms on a hospital-furnished form. The period of survey was from November 18, 1969, to February 6, 1970.

2. Research Method

(1) Automatic air pollution recorder

An automatic air pollution recorder (SR-350SD), manufactured by Kimoto Electronic Instruments Company, Inc. (Kimoto Denshi Keisoku Kabushiki Kaisha), was installed in a prescribed spot in a first floor hospital room. A tube for drawing in air was extended outdoors to the patio and placed about two meters above the ground. This tube drew in air at the rate of 10 cm^3/min, and the amount of suspended dust particles, sulfur dioxide, and anhydrous, sulfurous gases were constantly measured (measurements were taken on an hourly basis). The electrical conduction method was employed for sulfur dioxide, and a filter paper in the case of suspended particles to determine the degree of density. The hospital in which the test was conducted is located in a residential area of Meguro-ku, some 300 meters away from a heavy vehicular-trafficked thoroughfare (Yamate-dori). Access to the hospital is by a bridge spanning the 100 m wide Meguro River between the road and the hospital. This alleviated any fear of localized pollution impacting on the recorder in the hospital.

(2) Method of measurement

The daily maximum and average values for sulfur dioxide (ppm) and suspended particles (density percentage) were obtained from the tape on the recorder, and classified into three categories as follows:

Sulfur dioxde: average daily value (ppm): 0.1 or lower, 0.2 or lower, above 0.2.
Suspended particles: 30% or lower, 50% or lower, above 50%.

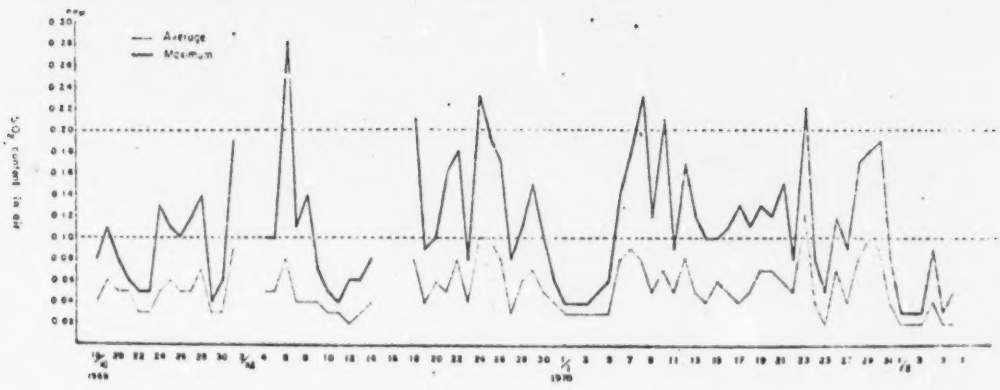


Figure 1. Daily changes of SO_2 content in air (November 18, 1969, to February 6, 1970).

Cases of stridor were also taken into account and included as symptoms of asthmatic attack. The number of patients who developed such attacks was noted daily.

3. FINDINGS

1. Changes in Air Pollution Conditions

During the period of observation, rain fell on 22 and 30 November, but the weather was fair most of the time (71 days) and cloudy during the remainder (8 days). On the whole, the weather was stable, although a cold wave set in on 28 December and 15 January.

As shown in Figures 1 and 2, the sulfur dioxde (SO_2) content ranged during the day between 0.03 and 0.28 ppm, with a high rate of pollution being noted in the afternoon. Variations in the daily average value were from 0.04 to 0.13 ppm. It was observed, in particular, that during the 6-day period between 31 December and 5 January, the maximum value of SO_2 remained at below 0.05.

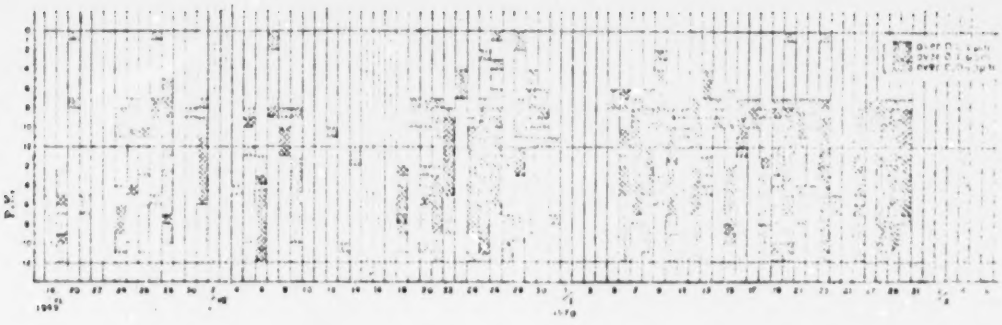


Figure 2. Hourly changes of SO_2 in air (November 18, 1969, to February 6, 1970).

Daily changes in the amount of suspended particles ranged from 5 to 60%, as shown in Figures 3 and 4. Unlike the case of SO_2, pollution does not increase in the afternoon, although it may appear so. Changes in the average daily value ranged between 5 and 40%. As with SO_2, the suspended particles remained at a minimum value during the period of 1 — 5 January.

For purposes of study of its link with asthmatic attacks, pollution is represented in the chart in three levels (shown by broken lines).

2. Daily Changes Affecting Asthmatic Conditions

Table 1 represents the daily record of asthmatic attacks kept by the patients. Table 2 is a composite prepared on the basis of records maintained by the fifteen patients. In Table 2, the letters F, Cl, and R denote fair, cloudy, and rainy weather, respectively, whereas X, ●, and O indicate the degree of pollution — as high, medium, or low — as described in the paragraph on the measuring method for air pollution. Broken lines denote no entry (because of prediagnosis or termination of hospital visits).

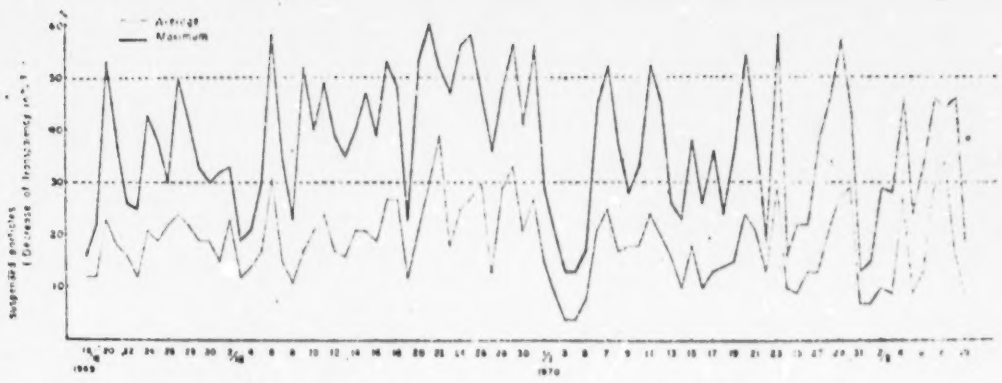


Figure 3. Daily changes of suspended particles in air (transparency decrease of filter paper in %) (November 18, 1969, to February 10, 1970).

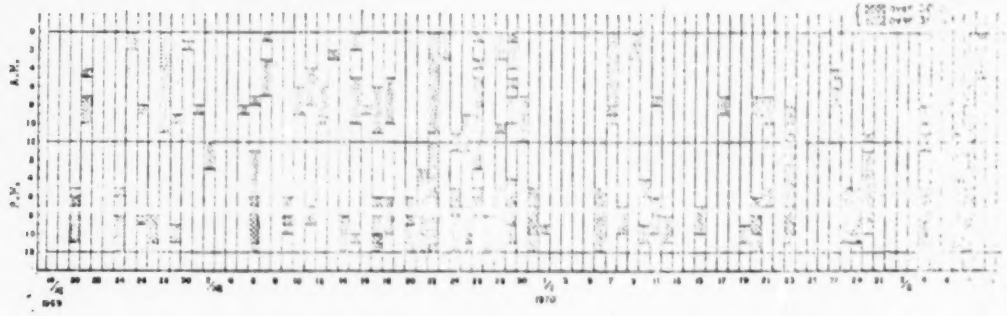


Figure 4. Hourly changes of suspended particles in air (transparency decrease of filter paper) (November 18, 1969, to February 10, 1970).

Table 3 summarizes Table 2.

In this Table 3, man-days are indicated (number of patients times number of days). The reason for this was that the number of persons examined varied daily. The incidence of asthmatic attacks was observed, not only on the day of occurrence, but on the next day as well.

TABLE 1

ASTHMATIC DIARY

November, 1969 Patient's Name: __ Female, 63 years old.

	Date	25			26			27			28			29			30			1			2			3			4		
		M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N	M	D	N
Attack condition	Major attack																														
	Intermediate attack																														
	Minor attack		○			○							○		○		○														○
	Wheezing				○				○	○								○	○												
	None																														
Symptoms	Sneezing																														
	Runny nose																														
	Coughing	○			○									○															○		
	Phlegm	○			○									○															○		
	Throat pain																														
	Fever																														
	Slight cold																														
Contributing factor for attack					Went out-doors				Bath-ing					*												Went out-doors			Bathing		
Weather		Fair			Fair			Fair			Fair			Fair			Rain			Fair			Fair			Fair			Fair		

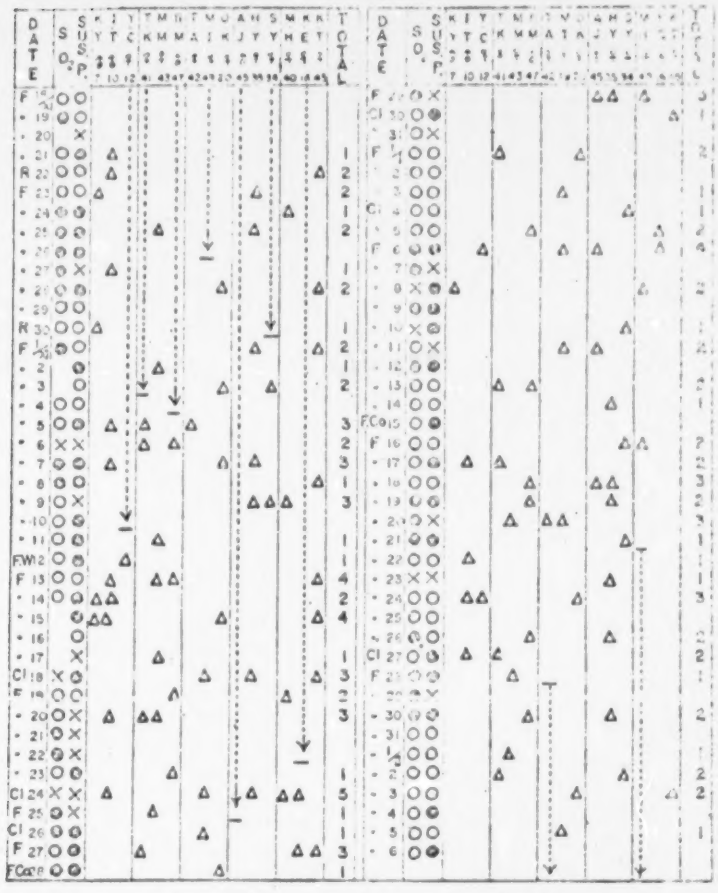
*Hypothermic injection at hospital.
M- morning; D- day; N- night.

As Table 3 and Figure 5 show, on the first day, sulfur dioxide (SO_2) appeared to assume a major role in pollution compared to suspended particles. The incidence of asthmatic attacks was greater on days when SO_2 registered a maximum value exceed 0.2 ppm. SO_2 registered a maximum value especially during a period of rising level of pollution (above 50%) by suspended particles.

A cursory examination of x2 revealed that the probability of the incidence of asthmatic attacks on days with a high value of SO_2 was around $5\% < P < 10\%$ ($x^2 = 4.98$, $n = 2$).

TABLE 2

INCIDENCE OF ASTHMATIC ATTACKS (WHEEZING)
IN RELATION TO AIR POLLUTION



Note. 1. F = Fine Weather, R = Rainy, Cl = Cloudy,
W = Windy, Co = Cold Wave,

Note. 2. × = highly polluted, ● = moderately polluted, O = low polluted

On days when SO_2 did not reach 0.2 ppm, the effects of suspended particles were secondary, since even its abundance did not necessarily lead to a higher incidence of asthmatic attacks. No conclusion could be reached on conditions on the succeeding day because it involved the question of whether a high level of pollution would continue for two days.

TABLE 3

RELATION BETWEEN ASTHMATIC ATTACKS (WHEEZING)
AND AIR POLLUTION (Nov. 18, 1969 — Feb. 6, 1970)

SO_2 ppm (Max) in a day	0.2 ≦		0.1 ≦			< 0.1			TOTAL
Susp. part. (Max) in a day	50% ≦	30% ≦	50% ≦	30% ≦	<30%	50% ≦	30% ≦	<30%	
man-days	40	43	107	177	44	55	171	321	958
The day Attacks	8	7	6	21	4	7	19	40	112
The day %	20.0	16.3	5.6	11.9	9.0	12.7	11.1	12.5	11.7
Next day Attacks	7	4	10	17	7	2	23	33	103
Next day %	17.5	9.3	9.3	9.6	15.9	3.6	13.5	10.3	10.8

4. DISCUSSION

Asthmatic attacks are induced by changes in environmental factors. As we previously reported [6], the weather plays the greatest role in this respect. After a study of weather conditions, including atmospheric pressure and humidity, it was found that their effect on asthmatic attacks could best be demonstrated by classifying such conditions into fair, cloudy, unsettled, or rain. Further study showed that cold weather and low temperature were probably the most crucial, being abetted by rising humidity.

During the period covered by this report, the weather was stable, there was hardly any rainfall, and average temperature was between 0 — 10° C, making it helpful in conducting the test on the effect of air pollution on asthmatic patients.

Because it would be meaningless to conduct an analysis if changes in air pollution as recorded by the recorder were different from those in air breathed by the patients, the location of the recorder in the hospital and the distance of the patient's home from the hospital were carefully considered. At first, a radius of one kilometer was decided upon, but was changed to two kilometers because of a lack of suitable patients.

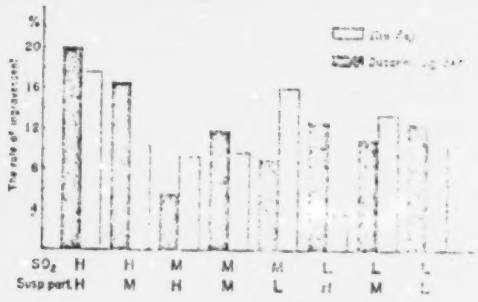


Figure 5. The relation between asthmatic attacks (wheezing) and air pollution.

It was necessary that the patients be exposed to a minimum of contagion and sensitive to the effects of the environment. Hence, asthmatic patients of the atopic type in light cases and not being administered steroids were selected for the test.

It was under such conditions that a comparison was made between between changes in the factors of air pollution, i.e., SO_2 values and suspended particles, and the incidence of asthmatic attacks. In this case, either the method of application of the maximum daily value or the average value could have been used in view of the hourly changes in the values of the pollution factors. In this report, the maximum value for one day was used in regard to air pollution factors as no clear-cut distinction was apparent between the average value for air pollution factors and the incidence of asthmatic attacks, probably due to the relatively short time involved in arriving at the maximum value, as shown in the charts. The degree of stimulation of the bronchial system should, of course, be indicated by the maximum value rather than the average value.

In summary, it was found that a high level of SO_2 pollution increases the frequency of asthmatic attacks, whereas suspended particles serve to enhance the effect of SO_2. This is probably due, as previously pointed out by Toyama and others [9], to SO_2 being absorbed by suspended particles and remaining in the bronchial system for a prolonged period.

Using the same patients, studies were also undertaken regarding changes in the rate of respiration, respiratory resistance, and the amount of SO_2, but details are omitted because of a lack of positive results.

In analyzing the changes in the incidence of asthmatic attacks according to days, the flexible 15-day average value method discovered by Holland and others were not applied, the reason being that time was short and weather conditions, apart from air pollution, were relatively stable.

It is interesting to note that there was virtually no air pollution during the New Year holidays from 31 December to 5 January.

5. RECAPITULATION AND CONCLUSION

A study to determine the changes in the incidence of asthmatic attacks based on the daily record of 15 outpatients residing in the neighborhood of a hospital in Tokyo-to and afflicted with bronchial asthma of the atopic type was conducted during the 81-day period between November 18, 1969, and February 6, 1970.

Meanwhile, an automatic air pollution recorder was installed in that hospital to obtain a running record of the amount of SO_2 and suspended particles in air.

A comparative study of the changes noted in the above cases confirmed that the incidence of asthmatic attacks tended to rise when the day's maximum value of SO_2 gas reached a high level of pollution (over 0.2 ppm), and that such incidence tended to rise even further along with an increase of suspended particles (50% or more absorbance).

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